(18) Grasslands

Description:

Grasslands are upland treeless areas dominated (> 80% cover) by herbaceous vegetation. Historically, parts of Maryland supported large expanses of natural grasslands and savanna-like habitats. Tens of thousands of acres of grassland dotted with Blackjack and Post Oaks once stretched across northern Maryland and nearby Pennsylvania. Prior to European settlement, much of Baltimore, Harford and Carroll Counties and adjacent counties in Pennsylvania were covered by this prairie-like grassland intermingled among wooded valleys (Mayre 1920). Also, early 18th and 19th century accounts depict large natural grasslands in the Hagerstown, Middletown and Frederick valleys (Mayre 1955) and around The Glades area of Garrett County. It is believed that these openings were created and maintained by a combination of soil conditions, large grazing mammals (e.g., woodland bison, elk) and periodic fires. These grassland ecosystems have since nearly vanished due to habitat loss resulting from development, agriculture, fire suppression and the disappearance of large ungulates. Most of the state's remaining grassland fauna mostly persists in one or more of the following settings: (1) agricultural fields (e.g., hayfields, pastures, certain croplands, grass buffer plantings); (2) fallow fields; (3) recent clearcuts (within 1-3 years after logging); (4) reclaimed strip mines on the Allegheny Plateau; (5) mowed edges of airports and military airfields; and (6) remnant natural grassland communities. Some grassland species of conservation concern also occur in nontidal and/or tidal marshes.

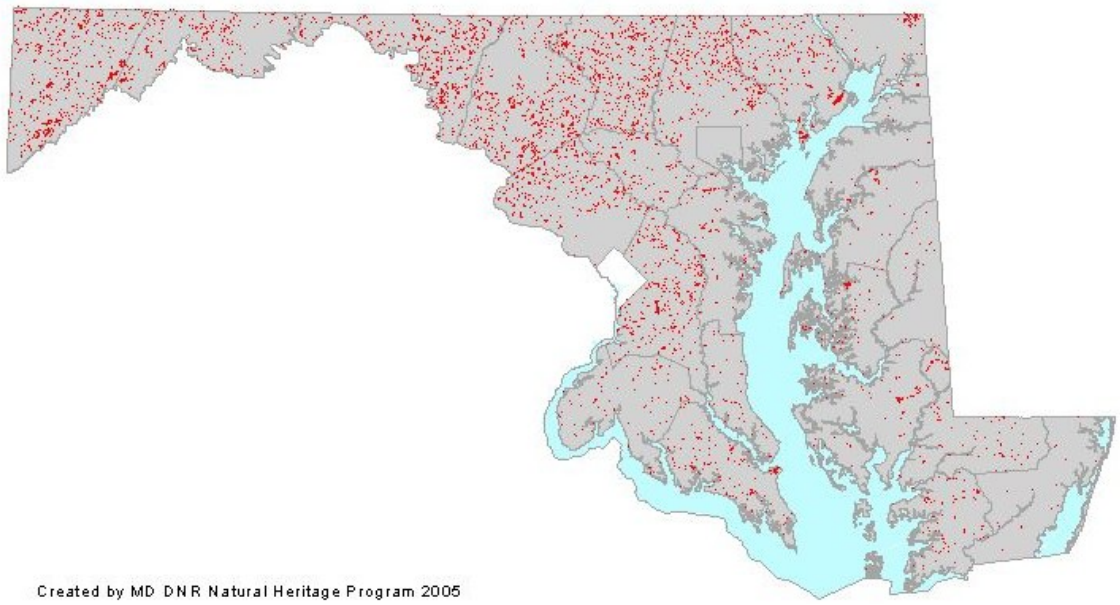
Grassland habitat suitability generally increases with the size and area:edge ratio of a grassland site. A number of grassland species (e.g., regal fritillary, grasshopper sparrow, Henslow's sparrow) are considered area-sensitive, occurring only in relatively large (> 50-100 ha), unfragmented grasslands and/or exhibiting positive, area-dependent changes in population density or viability. Depending on the taxon, other important predictors of habitat suitability may include vegetative composition, height, structure and patchiness; surrounding landscape conditions; and topography.

Location and Condition:

The grasslands that occurred in Maryland prior to European settlement have all but vanished. However, approximately 240,000 acres of anthropogenic grasslands occur in the state, much of it as pasture, hayfields, and fallow fields. The vast majority (89%) of this acreage is on private land. Some of the largest grasslands occur around commercial and military airfields like those at Aberdeen Proving Ground, Patuxent Naval Air Station and Baltimore-Washington International Airport. Expansive grasslands also occur on reclaimed strip mines

in western Allegany and Garrett Counties. Loss and fragmentation of agricultural land to development along with incompatible farming and mowing practices are among the most significant threats to grassland habitat and GCN species within this habitat in Maryland. Nearly all of the few remaining native grasslands occur as small isolated natural communities. Perhaps the best remaining example of a native grassland is located at Soldiers Delight Natural Environment Area in Baltimore County (see the section on "Barrens and Dry Glades" for details). Restoration of this globally rare serpentine habitat is on-going. With few opportunities for restoring native grasslands, especially on a scale large enough to support area-sensitive species and viable metapopulations of habitat specialists, the future of grassland habitat conservation in Maryland depends, in large part, on proper management of anthropogenic grasslands in a manner that does not compromise the conservation goals of native species and ecosystems.

Figure 4.18 Location of Grasslands in Maryland (Sources: MD Dept of Planning; MD DNR NHP)



GCN Species, Rare Natural Communities, and Other Wildlife:

Mammals
Bobcat
Eastern harvest mouse
Least shrew
Birds
American woodcock
Barn owl
Bobolink
Common nighthawk
Dickcissel
Eastern meadowlark

Field sparrow
Golden eagle
Grasshopper sparrow
Gull-billed tern
Henslow's sparrow
Laughing gull
Loggerhead shrike
Northern bobwhite
Northern harrier
Savannah sparrow
Sedge wren

Short-eared owl
Upland sandpiper
Vesper sparrow
Inverts: Butterflies & Moths
Indian skipper
Regal fritillary
Rare Natural Communities
Serpentine Barrens

In addition to the GCN species listed above, this key wildlife habitat supports a wide diversity of wildlife species. The following game species are found in this habitat type: white-tailed deer, black bear, red fox, coyote, common raccoon, striped skunk, long-tailed weasel, eastern cottontail, woodchuck, northern bobwhite, ring-necked pheasant, American woodcock, mourning dove, and American crow. Management plans and conservation programs for these game species are currently being implemented by MD DNR, USFWS, and many other partners.

Threats:

a. Conversion to other land uses or habitat types that results in loss of habitat
b. Pesticide use and contamination that directly or indirectly affects GCN species
c. Human disturbance and other incompatible practices that result in habitat degradation
d. Invasive species that result in habitat degradation
e. Lack of scientific understanding of appropriate habitat requirements and management for all GCN species
f. Fragmentation and isolation
g. Loss of natural fire regime
h. Lack of disturbance allowing succession over time
i. Incompatible mowing (time of year, mower height)
j. Aforestation

Conservation Actions:

a. Encourage beneficial agricultural practices, such as late mowing; involvement in the Conservation Reserve programs; and including grass forb buffers in agricultural settings ***[Measure: # of sites with cooperative management projects; # of acres farmland managed for this habitat]***

b. Incorporate conservation actions into land use and land planning efforts by local, state, and federal agencies ***[Measure: # of local, state, and federal agency plans incorporating wildlife focused habitat management actions]***

c. Develop and implement protocols to control invasive species in a manner compatible with GCN species ***[Measure: # of protocols developed and evaluated for effectiveness; # of sites with management implemented]***

d. Focus land preservation efforts on protecting large tracts of open grassland and minimize edge effects for area dependent grassland species ***[Measure: # of acres large tracts of grassland preserved]***

e. Restore and maintain native grassland communities ***[Measure: # of acres restored and maintained]***

f. Convert exotic pasture/hayland to native warm-season grasses *[Measure: # of acres exotic pasture/hayland converted to native warm-season grasses]*

g. Restore savannah conditions on private and public lands *[Measure: # of acres of savannah conditions restored]*

h. Encourage management for grassland species, including upland sandpipers, on airport lands and reclaimed mine lands *[Measure: # of wildlife focused habitat management guidelines incorporated into airport and reclaimed mine land management]*

i. Utilize appropriate prescribed burning in or light disking of selected portions of individual fields to maintain mid-successional seral stages and increase coverage of tall forbs *[Measure: # of acres maintained with controlled burn program; # of sites with natural fire regimes allowed]*

j. Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*
k. Incorporate best management practices into land management plans *[Measure: # of development BMPs developed; # of private and public land management plans implementing BMPs]*
l. Limit access and educate the public about the value of these habitats to minimize human disturbance *[Measure: # of sites with limited access and educational signage; # of educational materials developed and distributed]*
m. Minimize fragmentation of existing large grasslands used by GCN species *[Measure: # of land use projects developed in a manner that minimizes fragmentation]*
n. Utilize landowner incentive programs, including Farm Bill programs, to develop and maintain this habitat type *[Measure: # of acres created and maintained utilizing landowner incentive programs]*
o. Work with sportsmen organizations, such as Quail Unlimited, to promote and manage this habitat *[Measure: # of acres managed for this habitat type through cooperative projects with sportsmen organizations]*
p. Work with farmers to conserve and manage for this habitat on marginal croplands *[Measure: # of acres marginal cropland managed for this habitat type]*
q. Encourage the use of native seed stock for warm season grass plantings *[Measure: # of acres warm season grass plantings using native seed stock; # of educational materials developed and disseminated about sources and use of native seed]*
r. Convert agricultural fields on public lands to grassland habitat where feasible *[# acres converted]*

Inventory, Monitoring and Research Needs:

a. Initiate long-term monitoring studies of GCN species, including grassland nesting birds *[Measure: # of monitoring studies established; # of monitoring studies conducted]*
b. Conduct research on basic ecology, breeding parameters, and life histories of GCN species, especially insects *[Measure: # of research projects conducted; # of research papers published]*
c. Conduct research on habitat use and requirements of GCN species, including bobwhite, grassland birds, and insects *[Measure: # of research projects conducted; # of research papers published]*
d. Conduct species surveys and determine distribution and abundance of GCN species *[Measure: # of research projects conducted; # of research papers published]*
e. Conduct research to determine movement patterns and dispersal of GCN species *[Measure: # of research projects conducted; # of research papers published]*
f. Develop standardized regional monitoring protocols for GCN species *[Measure: # of standardized protocols developed]*
g. Identify agricultural practices beneficial to GCN grassland species, including appropriate mowing regimes *[Measure: # of research projects conducted; # of research papers published; # of BMPs developed]*
h. Implement accurate and standardized survey methods to determine regional population trends *[Measure: # of surveys completed]*
i. Monitor success of populations in different habitat types, including restoration efforts *[Measure: # of monitoring studies established; # of monitoring studies conducted]*
j. Conduct studies on the limiting factors and management needs of GCN populations *[Measure: # of research projects conducted; # of research papers published]*
k. Conduct a comprehensive survey of grassland habitats and determine how they can be preserved *[Measure: # of surveys completed]*
l. Determine historical extent, range, and condition of native grassland communities *[Measure: Historical extent, range, and condition of native grassland communities determined]*

m. Compare habitat succession of fallow fields to that of planted grasslands for GCN species benefits *[Measure: # of research projects conducted, # of research papers published]*

(19) Barrens and Dry Glades

Description:

In Maryland, barrens and dry glades include habitats that have developed on shallow soils over bedrock of serpentine, sandstone, and shale. The plant communities associated with them are structurally intermediate between forests and open canopy uplands, often consisting of sparse woodlands, shrublands, and grass-savannas. Most of these habitats are kept from succeeding to closed forests by periodic fire, edaphic factors, and unstable substrates. Serpentine soils derive from ultramafic rocks, which occur in a discontinuous band east of the Appalachian Mountains from Canada to Alabama. Serpentine Barrens are best developed in the Piedmont of southeastern Pennsylvania and northern Maryland. One of the four remaining serpentine areas in Maryland, the Soldiers' Delight Natural Environmental Area near Baltimore, is the largest in eastern North America, encompassing 2,000 acres of woodlands and grassland savannas, and is among the most species-rich in the world. Serpentine, or serpentinite, is a mineral producing dry, nutrient-poor soil deadly to plants not specially adapted to its unusual chemistry. In folklore, the name "serpentine" is attributed to the soil's resemblance to a mottled greenish-brown snake dwelling on similar soils in northern Italy. The greenish soil color comes from fragments of the underlying bedrock containing magnesium silicate. Toxic to plants, as much as one-third of the bedrock may be made of magnesium. The soil can be very dark in color, depending on its iron, chromite, and magnesium content. High levels of magnesium in the soil block a plant's ability to take in soil nutrients, especially calcium. Because they are shallow and low in organic material and clay, serpentine soils also cannot hold water or nutrients well. Serpentine soils often have pockets of naturally occurring heavy metals toxic to plants, such as chromium, cobalt, and nickel. Also, these soils are normally acidic near the surface, but less so in deeper layers. As wind and water erode the soil, non-acidic layers are exposed, creating varied habitat for plants. Plants characteristic of serpentine barrens include little bluestem, Indian grass, purplish three-awn grass, serpentine aster, and roundleaf fameflower. Woodlands bordering grassland vegetation consist of common greenbrier, blackjack oak, post oak, and the fire-intolerant Virginia pine.

Shale barrens consist of sparse woodlands with scattered herbaceous openings on rock outcrops of acidic and calcareous shales in the Ridge and Valley physiographic province of Maryland. They are best developed on steep, dry slopes with south to west-facing exposures where surface temperatures are seasonally extremely high. In addition, shales are highly friable and many steep slopes contain loose and unstable channery derived from the continual undercutting of bedrock by streams. This mechanical erosion from constant downslope movement of loose fissile shale combined with very little soil development, very low soil

moisture, rapid water drainage, lack of shading vegetation, and longer daily/annual exposure to the sun (due to southerly aspect) results in harsh growing conditions and drought stress. Only species well adapted to these harsh conditions thrive in such habitat. These conditions favor the development of open woodlands containing stunted trees of chestnut oak, Virginia pine, eastern red cedar, and pignut hickory. Other characteristic trees include white ash, post oak, black oak, red oak, table-mountain pine, white pine, shagbark hickory, and pignut hickory. Shrubs common to shale barrens include shadbush, black huckleberry, deerberry, and bear oak. Calcareous shales often include shrubs such as shrubby St. Johnswort, fragrant sumac, dwarf sumac, and Carolina rose. Herbaceous openings are sparsely vegetated and often scattered within a woodland matrix. Such openings contain many endemic or near-endemic shale barren species such as shale-barren pussytoes, shale-barren ragwort, shale-barren evening primrose, low false bindweed, and Kate's-mountain-clover. Also characteristic are species such as Pennsylvania sedge, wavy hairgrass, common dittany, rattlesnake-weed, poverty oat-grass, little bluestem, northern moss phlox, birdfoot violet and reindeer lichens.

Sandstone glades are characterized by scrub and herbaceous vegetation on exposed acidic sandstone outcrops in the Allegheny Plateau physiographic province of the Central Appalachian Mountains in Maryland. The vegetation is best characterized as a mosaic of scrub thickets, herbaceous openings, and exposed bedrock with substantial lichen growth. Plant growth is typically confined to crevices or depressions where organic material has accumulated over time. Sandstone glades exhibit very harsh growing conditions resulting from very little soil development, low moisture retention, rapid runoff, and often great sun exposure. Combined these conditions make sandstone glades extremely drought-prone. Woody scrub usually consists of scattered, stunted trees of chestnut oak, bear oak, black gum, black birch and shrub thickets of black huckleberry, early low blueberry, northern lowbush blueberry, and glaucus greenbrier. Openings in the woody scrub are interspersed and if the right conditions are present, they typically support herbaceous species such as wintergreen, little bluestem, broomsedge, Pennsylvania sedge, and oat-grasses. Reindeer lichens are especially abundant.

Limestone glades are small, localized habitats of exposed carbonate rock outcrops in the Ridge and Valley physiographic province of Maryland. Habitats typically occur on dry, steep, south to west facing slopes containing very shallow soils and variable amounts of exposed bedrock and gravel. Soils are characterized by high pH (>7.0) and calcium levels, thus supporting a variety of calciphiles. The vegetation structure of limestone glades is best described as scrub with scattered herbaceous openings. Characteristic species include stunted trees and shrubs of chinkapin oak, eastern red cedar, white ash, red bud, common hackberry, fragrant sumac, American bladdernut, and common prickly-ash. The herbaceous layer often contains warm-season prairies grasses such as side-oats grama and little bluestem mixed with hoary puccoon, downy woodmint, bottlebrush grass, and hoary mountain-mint. In addition, ledges and crevices may support northern moss phlox and purple-stem cliff-brake.

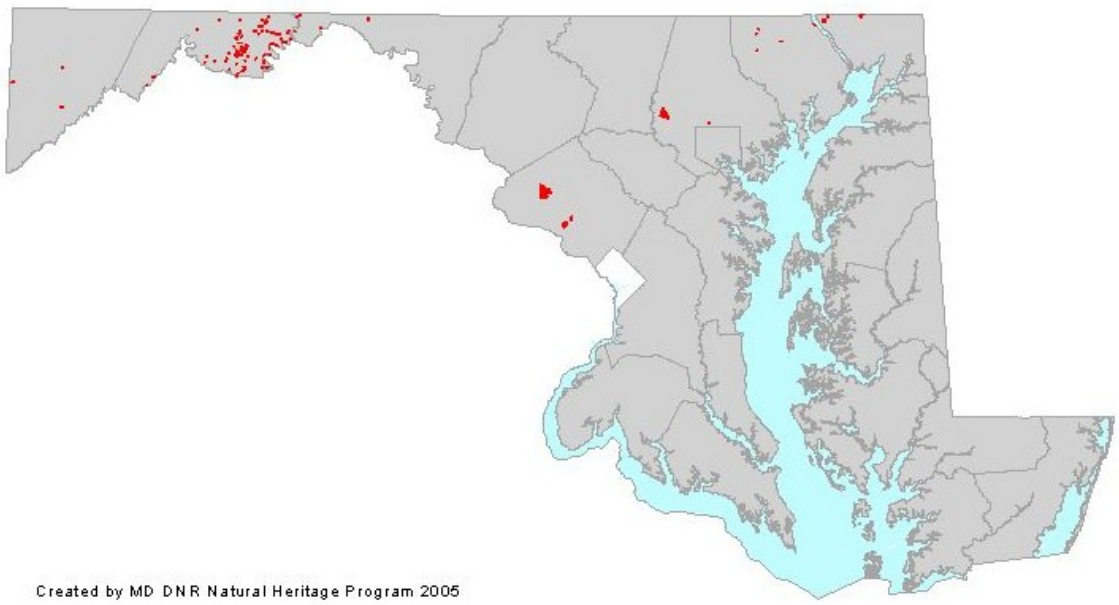
Location and Condition:

Prior to European settlement (circa 1750), serpentine barrens and grasslands covered expansive areas in Maryland, concentrated in the upper portions of Baltimore, Harford, and Carroll Counties (Mayre 1920). Although edaphic factors are generally thought of as major contributors to serpentine habitats, use of fire by Amerindians prior to settlement was even a larger contributor in maintaining barren conditions. Between 1580 and 1730, the Susquehannock Indians and other tribes used these areas to harvest deer by "fire hunting". This practice has since been determined to be responsible for maintaining vegetative conditions on serpentine barrens throughout this region (Mayre 1955). Following European settlement and well into the 1900s, most of the barrens became farmed, grazed, or left to succeed into wooded timber following the absence of fire. Today, remaining examples are threatened by the invasion of fire intolerant Virginia pine and thickets of common greenbrier. And frequent prescribed burns are necessary to maintain them. Examples of serpentine barrens in Maryland are known from Soldiers' Delight Natural Environmental Area, Cherry Hill, Robert E. Lee Park, and Pilot Preserve (TNC). Soldiers' Delight Natural Environmental Area remains the largest (nearly 2,000 acres) and best example.

Shale and sandstone barrens are small, localized habitats found in Garrett and Allegany Counties. Examples of shale barrens are scattered throughout Green Ridge State Forest. The primary threat to most shale barrens is invasion by exotic species such as barren bromegrass, cheat grass, Japanese bromegrass, spotted knapweed, Japanese honeysuckle, garlic-mustard, and tree-of-heaven. In Garrett County, excellent examples of sandstone glades can be found in Savage River State Forest on Big Savage and Meadow Mountains. In Allegany County, examples of sandstone glades are known from Martin and Warrior Mountains. The majority of sandstone glades are in good condition with only a few threatened by invasives such as tree-of-heaven, which can quickly colonize recently logged adjacent habitats.

The best remaining examples of Limestone glades are found on Fort Hill in Allegany County. A few scattered, degraded occurrences have also been documented from the Frederick Valley. These habitats are considered state-rare, small, highly localized, and threatened by invasive exotic species, quarrying, and grazing. There are at least 6,920 acres of barrens and dry glades in Maryland, of which most is either owned by private landowners (37.6%) or owned and managed by the state (33.8%). The rest is owned by the federal government (3.1%), by county/municipal agencies (23.4%), or by non-profit conservation organizations (2.1%).

Figure 4.19 Location of Barrens and Dry Glades in Maryland (Source: MD DNR NHP)



GCN Species, Rare Natural Communities, and Other Wildlife:

Mammals
Allegheny woodrat
Bobcat
Eastern harvest mouse
Eastern red bat
Least shrew
Silver-haired bat
Birds
Brown thrasher
Chuck-will's-widow
Common raven
Eastern meadowlark
Eastern towhee
Field sparrow
Golden-winged warbler
Grasshopper sparrow
Ovenbird
Prairie warbler
Whip-poor-will

Reptiles
Broad-headed skink
Cornsnake
Eastern hog-nosed snake
Timber rattlesnake
Inverts: Butterflies & Moths
A geometrid moth
A noctuid moth
Cobweb skipper
Dotted skipper
Edwards' hairstreak
Frosted elfin
Giant swallowtail
Indian skipper
Mottled duskywing
Northern crescent
Northern hairstreak
Northern metalmark
Olympia marble

Pepper and salt skipper
Persius duskywing
Pine barrens zanclognatha
Silvery blue
Southern grizzled skipper
The buckmoth
Inverts: Homopterans
Eastern sedge barrens planthopper
Inverts: Beetles
Cow Path Tiger Beetle
Splendid Tiger Beetle
Rare Natural Communities
Central Appalachian Shale Barrens
Sandstone Glades
Serpentine Barrens
Limestone Glades

In addition to the GCN species listed above, this key wildlife habitat supports a wide diversity of wildlife species. The following game species are found in this habitat type: white-tailed deer, eastern gray squirrel, eastern fox squirrel, red fox, common gray fox, coyote, common raccoon, Virginia opossum, striped skunk, long-tailed weasel, woodchuck,

wild turkey, ruffed grouse, northern bobwhite, mourning dove, and American crow. Management plans and conservation programs for these game species are currently being implemented by MD DNR, USFWS, and many other partners.

Threats:

a. Conversion to other land uses or habitat types that results in loss of habitat
b. Lack of periodic fire
c. Pesticide use and contamination that directly or indirectly affects GCN species
d. Human disturbance and other incompatible practices that result in habitat degradation
e. Invasive species that result in habitat degradation
f. Lack of scientific understanding of appropriate habitat requirements and management needs for all GCN species
g. Fragmentation and isolation
h. Resource utilization from mining and wind farms
i. Succession
j. Deer overbrowsing or other causes that result in loss of structural diversity
k. Towers that fragment and degrade habitat

Conservation Actions:

a. Develop habitat management guidelines for use by foresters and land managers ***[Measure: habitat management guidelines developed]***

b. Incorporate conservation actions into land use and land planning efforts by local, state, and federal agencies ***[Measure: # of local, state, and federal agency plans incorporating wildlife focused habitat management actions]***

c. Work with private landowners to maintain suitable habitat, including the use of a private lands registry program ***[Measure: # of acres habitat conserved; # of landowners participating in private land registry program]***

d. Develop and implement protocols to control invasive species in a manner compatible with GCN species ***[Measure: # of protocols developed; # of sites with management implemented]***

e. Restore and maintain habitat through re-establishing natural fire regimes where feasible and conducting controlled burns ***[Measure: # of acres maintained with controlled burn program; # of sites with natural fire regimes allowed]***

f. Conserve appropriate corridors for movement and dispersal of GCN species ***[Measure: # of acres corridors conserved; # of acres existing barrens and dry glades connected by corridors]***

g. Minimize fragmentation *[Measure: # of development projects and land use plans that incorporate measures to minimize habitat fragmentation]*

h. Restore degraded sites *[Measure: # of acres restored]*

i. Incorporate best management practices into land management plans *[# of development projects and other land management plans implementing BMPs]*

j. Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*

k. Control deer populations to reduce browsing levels *[Measure: # of acres with reduced deer browsing levels]*

l. Limit access and educate the public about the value of these habitats to minimize human disturbance *[Measure: # of sites with limited access and educational signage; # of educational materials developed and distributed]*

Inventory, Monitoring and Research Needs:

a. Conduct targeted inventories of certain GCN species *[Measure: # of surveys completed]*
b. Conduct long-term monitoring of certain GCN species *[Measure: # of monitoring studies established; # of monitoring studies conducted]*
c. Conduct research on movement patterns, population trends and basic biology of certain GCN species *[Measure: # of research projects conducted; # of research papers published]*
d. Conduct research on effects of pesticide use on GCN species, especially invertebrates *[Measure: # of research projects conducted; # of research papers published]*
e. Conduct habitat research to determine the best management practices and the effects from fire *[Measure: # of research projects conducted; # of research papers published; # of BMPs developed]*
f. Determine natural fire regime *[Measure: # of research projects conducted; # of research papers published]*

(20) Cliffs and Rock Outcrops

Description:

Rock outcrops and cliffs are tall (up to 50 m high), steep to vertical expanses of bare to sparsely vegetated bedrock and/or soil. The differences between the two are subtle but cliffs are generally considered tall, sheer vertical walls of rock or soil while outcrops consist of steep to vertical, exposed rock formations with well-developed fissures and crevices. Both are most numerous and prominent in the Allegheny Plateau and Ridge and Valley physiographic regions, although significant examples also occur in the Piedmont and along parts of the Chesapeake Bay shoreline.

On the Allegheny Plateau, this habitat is typified by extensive (in places at least 0.5 km long) Pottsville sandstone outcrops along the upper slopes and ridges (600-1000 m) of the state's highest mountains, including Dan's, Big Savage, Meadow and Backbone Mountains. In the Ridge and Valley, large sandstone ridgetop outcrops also occur in the Tuscarora Formation on Haystack, Wills and Evitts mountains, and in the Bear Pond Mountains; the Purslane Formation on Sideling Hill and Town Hill; and in the Oriskany Formation on numerous ridges such as Fort Hill, Rountop Hill and Warrior Mountain. Farther east, between Hagerstown and Frederick, the Weverton Quartzite Formation forms major outcrops along the crests of South and Catoctin Mountains. Many of these outcrops include massive cliff and boulder faces with numerous, deep fissures. The outcrop base is often surrounded by extensive, open talus that grades into forested boulder fields. Cool, windswept conditions along with frequent ice storms and heavy snows greatly limit soil development and, thus, the type and extent of plant communities present. Vegetation in and around outcrops also varies depending on the physiographic region, elevation, slope, aspect, geological formation and other factors. On the steepest, most exposed sections, vegetation is absent except for patches of lichens and mosses growing on rock surfaces. On less exposed areas, scattered, sometimes dense patches of shrubs (e.g., mountain laurel, great-laurel), huckleberry, and blueberry along with scattered, stunted trees (e.g., chestnut oak, pitch pine, America mountain-ash, table mountain pine, and eastern hemlock) may be present. The surrounding vegetation, which influences the types of outcrop fauna present, ranges from northern conifer-hardwoods and mesic deciduous forest to dry oak-pine forest. Prior to the introduction of chestnut blight in the early-mid 1900's, American chestnut was a frequent to dominant tree species in many of the forests surrounding ridgetop outcrops.

At lower elevations in western Maryland, large outcrops and cliffs also occur along many of the larger streams and rivers. In Garrett County, for example, Pottsville sandstone outcrops

overlook sections of the Youghiogheny River and North Branch of the Potomac River. A variety of formations outcrop along the main stem of the Potomac. One spectacular example is the Weverton Quartzite Formation which forms tall, sheer cliffs near Harper's Ferry and Point of Rocks. Shale and limestone outcrops and ledges also occur along the Potomac in Allegheny, Washington and Frederick counties.

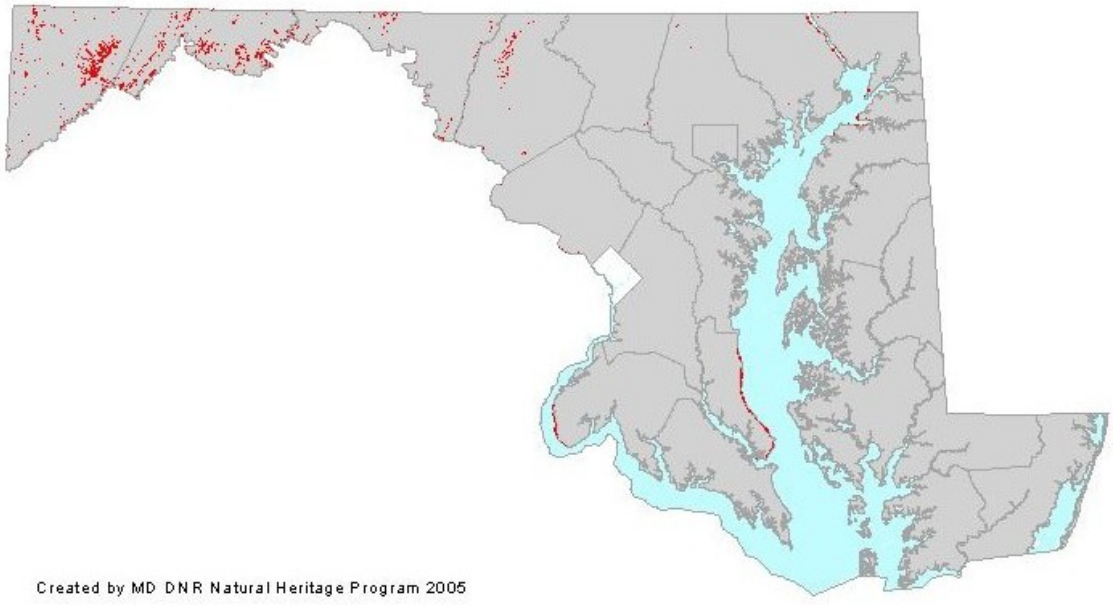
Cliffs and outcrops are much less common in the Piedmont and most are relatively small. The largest occur along the Susquehanna River, on Sugarloaf Mountain and in the Great Falls region of the Potomac River. On the Coastal Plain, this habitat type is limited to tall (5-40 m), steep to vertical earthen bluffs of Miocene origin along the shorelines of the mid- and upper Chesapeake Bay and large tidal rivers. Calvert Cliffs in Calvert County and Grove Point at the mouth of the Sassafras River typify this habitat type. Vegetation is usually absent to sparse due to naturally high erosion rates resulting from a combination of shoreline wave action, groundwater percolation and the weathering effects of wind and precipitation, especially during major storm events (e.g., hurricanes and "nor'easters"). A sparse early successional community may become temporarily established on less steep or exposed cliff faces. Vegetation composition varies but small trees such as black locust and sassafras are among the more frequent tree species present. Smaller (3-8 m tall) earthen bluffs also occur along inland rivers such as the Potomac and Monocacy. Large quarries and borrow pits occasionally serve as surrogate habitats for some cliff- and bluff-dwelling wildlife species.

Location and Condition:

Most cliffs and rock outcrops occur in mountain ridgetop settings in western Maryland; however, scattered outcrops are located in the Piedmont with the largest ones occurring along the Susquehanna River. Some of the largest, most ecologically significant examples exist along Big Savage Mountain and Backbone Mountain in Garrett County, Wills Mountain in Allegany County, and the Catoctin Mountains in Frederick and Washington Counties. Although few areas of cliff and rock outcrop ecosystems have been destroyed, many areas are significantly threatened by logging, introduced insect pests (e.g., gypsy moth, hemlock wooly adelgid), acid precipitation, vandalism and excessive human disturbance, and invasive plant species. Windpower development on ridgetops also poses a very serious new threat.

On the Coastal Plain, tall earthen bluffs occur along the Chesapeake Bay shoreline, with the most spectacular examples in Calvert, Kent and Cecil Counties. These naturally eroding cliffs are severely threatened by shoreline erosion control practices that alter or reduce natural erosion processes. The effects of sea-level rise are also of great concern.

Figure 4.20 Location of Cliffs and Rock Outcrops in Maryland (Sources: MD DNR NHP; USGS NED)



GCN Species, Rare Natural Communities, and Other Wildlife:

Mammals
Allegheny woodrat
Bobcat
Eastern small-footed myotis
Eastern spotted skunk
Indiana bat
Least weasel
Long-tailed shrew
New England cottontail
North American Porcupine
Birds
American peregrine falcon

Bank swallow
Common raven
Dark-eyed junco
Mourning warbler
Winter wren
Reptiles
Cornsnake
Eastern hog-nosed snake
Timber rattlesnake
Amphibians
Green salamander
Inverts: Beetles

Cow Path Tiger Beetle
Northern Barrens Tiger Beetle
One-spotted Tiger Beetle
Puritan tiger beetle
Inverts: Land Snails
Cherrydrop snail
Rader's snail
Rare Natural Communities
Piedmont/Mountain Cliffs
Riverside Outcrop Barrens

In addition to the GCN species listed above, this key wildlife habitat supports a wide diversity of wildlife species. The following game species are found in this habitat type: white-tailed deer, black bear, common gray fox, common raccoon, Virginia opossum, striped skunk, long-tailed weasel, woodchuck, wild turkey, ruffed grouse, American crow, and fish crow. Management plans and conservation programs for these game species are currently being implemented by MD DNR, USFWS, and many other partners.

Threats:

a. Conversion to other land uses or habitat types that results in loss of habitat
b. Pesticide use and contamination that directly or indirectly affects GCN species
c. Human disturbance and other incompatible practices that result in habitat degradation

d. Invasive species that result in habitat degradation
e. Lack of scientific understanding of appropriate habitat requirements and management for all GCN species
f. Fragmentation and isolation
g. Incompatible silviculture, wind farms, and mining that result in habitat degradation
h. Inappropriate shore erosion control
i. For sand and clay cliffs, nutrient loading from septic systems that enhance vegetation establishment

Conservation Actions:

a. Develop habitat management guidelines for use by foresters and land managers and work with them to implement such ***[Measure: guidelines developed; # of sites with cooperative management project; # of acres of this habitat managed for GCN species]***

b. Provide adequate forest buffers ***[Measure: # of acres of adequate forested buffers established]***

c. Develop and implement shore erosion control practices that are compatible with cliff maintenance and the needs of GCN species ***[Measure: # of BMPs developed; # of projects that incorporate BMPs into land management efforts]***

d. Educate the general public, land owners, and land managers about the value of these habitats ***[Measure: # of educational materials developed and distributed]***

e. Incorporate conservation actions into land use and land planning efforts by local, state, and federal agencies ***[Measure: # of local, state, and federal agency plans incorporating wildlife focused habitat management actions]***

f. Limit access to minimize human disturbance ***[Measure: # of sites with limited access]***

g. Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*

h. Reduce impacts of wind turbines through appropriate siting/micrositing *[Measure: # of new wind turbine plans that incorporate comments/input for siting to minimize impacts]*

i. Incorporate best management practices into land management plans *[# of development projects and other land management plans implementing BMPs]*

j. Minimize fragmentation *[Measure: # of development projects and land use plans that incorporate measures to minimize habitat fragmentation]*

k. Maintain functioning subsurface habitats *[Measure: # of acres with functioning subsurface habitats]*

l. Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*

m. Reintroduce blight resistant American chestnut to appropriate rock outcrops *[Measure: # of sites with blight resistant American chestnut restored]*

n. Work with climbing clubs to minimize degradation and disturbance *[Measure: # of groups with cooperative management projects; # of sites with human disturbance minimized]*

Inventory, Monitoring and Research Needs:

a. Conduct long-term monitoring studies of GCN species, including woodrats and Puritan tiger beetles *[Measure: # of monitoring studies established; # of monitoring studies conducted]*

b. Conduct research on basic ecology, breeding parameters, and life histories of GCN species *[Measure: # of research projects conducted; # of research papers published]*

c. Conduct research on habitat use and requirements of GCN species, especially invertebrates *[Measure: # of research projects conducted; # of research papers published]*

d. Conduct species surveys and determine distribution and abundance of GCN species, especially invertebrates *[Measure: # of surveys completed]*

e. Conduct research to determine movement patterns and dispersal of GCN species, including woodrats, reptiles, and tiger beetles *[Measure: # of research projects conducted; # of research papers published]*
f. Determine forest matrix requirements to sustain functionality of these habitats *[Measure: # of research projects conducted; # of research papers published; forest matrix requirements determined]*
g. Conduct research to determine best management practices for GCN species *[Measure: # of research projects conducted; # of research papers published; # of BMPs determined]*

(21) Caves, Mines, and Springs

Description:

Caves are natural underground cavities or tunnels. They contain unique, fragile environments that support highly specialized animal communities and often a variety of rare species. Over 160 caves have been documented in Maryland. Most are located in the Ridge and Valley and Allegheny Plateau physiographic regions, but a few small caves occur in the Piedmont. Caves are most numerous in Washington County followed by Allegany, Garrett and Frederick counties. Crabtree Cave in Garrett County is the largest with over 1,200 m of passage. Two general types of caves exist in Maryland: solutional and non-solutional caves. The latter are formed by mechanical processes, occurring as joints or fractures in bedrock. Fissure caves and rock shelters are examples of this cave type. They are less numerous than solutional caves and are usually relatively small, shallow and lack extensive passageways. They occur in a variety of rock formations including the Pottsville Sandstone Formation in Garrett County, Tuscarora Sandstone Formation in Allegany and Washington counties, and Weverton Quartzite Formation in Frederick County. Solutional caves, however, can be quite deep and extensive and they represent, by far, the largest caves in Maryland. They are formed by the dissolving action of groundwater, which is naturally slightly acidic, on soluble, carbonate rock (usually limestone). Over millennia, these and related processes lead to the development of complex passages or tunnels and various speleothems or "formations" (carbonate deposits on cave surfaces) such as stalagmites, stalactites, helictites, and cave "coral". Some caves also contain subterranean streams that are hydrologically linked to karst landforms such as sinkholes, sinking streams, and springs. Solutional caves and other karst features are most numerous in the Tomstown Limestone Formation in Washington County which contains massive dolomites and limestones over 300 m thick. Other important cave-bearing formations include the Greenbrier Formation in Garrett County and the Tonoloway, Waynesboro, Beekmantown and Stones River formations in Washington County.

Mines are human-made underground tunnels from which coal and other mineral resources (e.g., limestone, copper, gold, chromium) are extracted. Most occur on the Allegheny Plateau but some smaller, now inactive mines also occur in the Ridge and Valley and Piedmont regions. Most rare cave-dwelling species are absent in mines. However, some abandoned mines can provide surrogate or cave-like habitat for a limited number of cave-dwelling species, especially more mobile vertebrates such as bats. The habitat suitability of abandoned mines for cave-dwelling animals depends on a variety of factors but especially the level of human disturbance, mine size and depth, passage complexity, rock formation type, temperature, humidity, and the presence or absence of groundwater.

A spring is a concentrated discharge of groundwater at a small (usually < 1 m^2), distinct site or opening in the ground. Springs are uncommon, isolated features and most occur west of the Fall Line. They provide critical habitat for highly rare aquatic snails and subterranean invertebrates, salamanders, crayfish and other invertebrates. Because some springs discharge directly into streams or wetlands, they also play a vital role in maintaining the ecological integrity of these habitats that, in turn, may harbor species of conservation concern (e.g., pearl dace, brook trout, rare dragonflies and damselflies). Springs emit groundwater due to hydrostatic pressure resulting from gravity or artesian flow, although other physical forces may play a role (e.g., buoyant effect of dissolved gases). Several types of springs exist in Maryland including contact, scree, and fault springs. Perhaps the most common type is fracture or crevice springs. Here, groundwater moves downward due to gravity, flowing through fractures and crevices underneath the ground and emerging as a spring where a major fracture in a rock formation occurs at the earth's surface, usually along a ravine or swale. The flow or discharge rate of Maryland's springs ranges from less than one gallon per minute to nearly 10,000 gallons per minute. Seeps differ from springs in that they appear on the ground surface as broad, diffuse zones of wetness or percolation rather than distinct discharge sites. Also, seeps and associated wetlands often support distinct plant communities while springs are essentially aquatic and geological features.

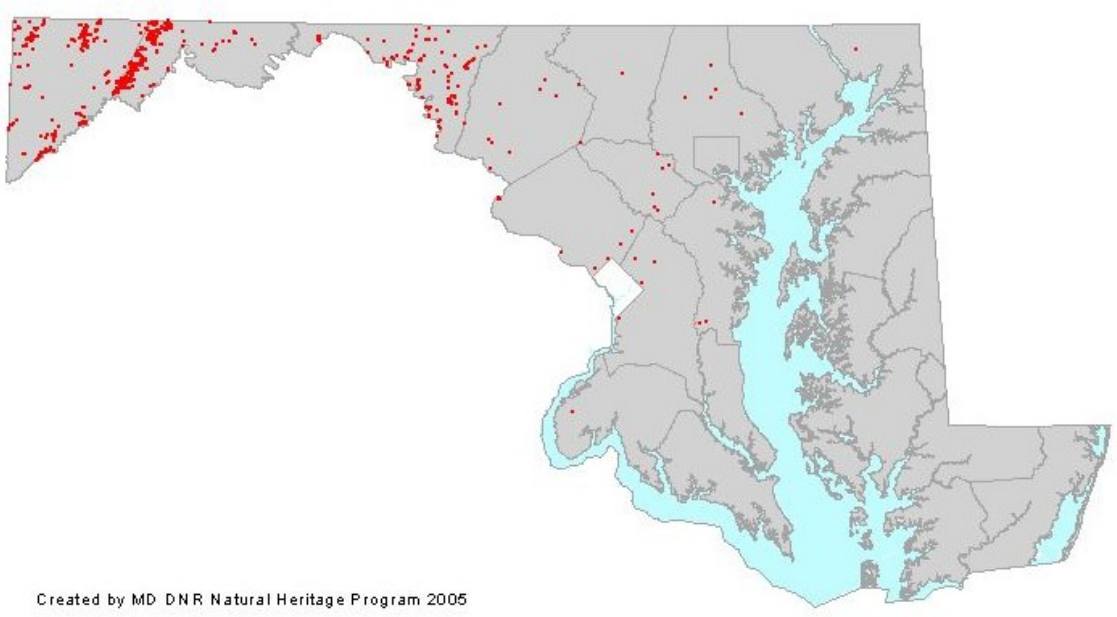
Location and Condition:

Nearly all of Maryland's caves are confined to the four westernmost counties, and most of these are located in Allegany and Washington Counties. The two most significant threats to caves are vandalism and groundwater pollution from development and agriculture. Many caves have suffered the effects of one or both of these. Over 90% of all caves are on private land and few cave systems are fully protected, especially when one considers that protection of the surrounding catchment basin or watershed is often as critical as securing the cave entrance.

Like caves, most of Maryland's springs occur in western Maryland but scattered springs also occur in the Piedmont and, to a lesser degree, the Coastal Plain. Nearly all mines occur in large coal seams in western Allegany and Garrett Counties. Much remains to be learned about the number, location and condition of springs and mines but, clearly, they face many of the same conservation issues as caves.

DNR's Natural Heritage Program compiled information on 1,114 caves, mines and springs in Maryland, of which only 215 (19 %) are caves and springs. The majority of this key wildlife habitat is found on privately-owned land (93%). The others are owned by the federal government (2.3%), state government (3.3%), private conservation organizations (0.7%), various county/municipal agencies (0.6%), or are on lands with conservation easements (0.6%).

Figure 4.21 Location of Caves, Mines and Springs in Maryland (Sources: MD DNR MGS; UMD AEL; USGS NHD; USGS GNIS; MD DNR NHP)



GCN Species, Rare Natural Communities, and Other Wildlife:

Mammals
Allegheny woodrat
Eastern small-footed myotis
Indiana bat
Southeastern myotis
Amphibians
Long-tailed salamander
Inverts: Beetles
A cave beetle
Inverts: Springtails
Crabtree cave springtail
Inverts: Spiders
Appalachian cave spider
Snivelys cave spider
Inverts: Freshwater Crustaceans
A harpacticoid copepod

Allegheny cave amphipod
An amphipod
An isopod
An isopod
An isopod
An isopod
An isopod
An isopod
Barrelville amphipod
Biggers' cave amphipod
Dearolf's cave amphipod
Franz's cave amphipod
Franz's cave isopod
Greenbrier cave amphipod
Pizzini's amphipod
Potomac amphipod
Price's cave isopod

Roundtop amphipod
Shenandoah cave amphipod
Tenuis amphipod
Tidewater amphipod
Inverts: Snails
Appalachian spring snail
Blue ridge spring snail
Inverts: Flatworms
A planarian
A planarian
A planarian
A planarian
Hoffmaster's cave planarian
Rare Natural Communities
N/A

In addition to the GCN species listed above, this key wildlife habitat supports a diversity of other wildlife species. No game species are found in this habitat type.

Threats:

a. Conversion to other land uses or habitat types that results in loss of habitat

b. Pesticide use and contamination that directly or indirectly affects GCN species
c. Human disturbance and other incompatible practices that result in habitat degradation
d. Invasive species that result in habitat degradation
e. Lack of scientific understanding of appropriate habitat requirements and management for all GCN species
f. Habitat degradation due to strip mining, logging, road construction and salt application, agriculture, overgrazing, and development of watershed areas
g. Pollution of groundwater from pesticides (such as dimlin), toxins, and nutrient overload
h. Hydrologic disturbances, siltation, groundwater flow alteration, and disturbances of recharge areas affecting water flow or quality
i. Fragmentation of habitat
j. Vegetation removal at upwellings resulting in loss of allochthonous input
k. Spelunker disturbances to caves and mines resulting in compaction of littoral zone

Conservation Actions:

a. Limit land use changes that may impact hydrology ***[Measure: # of acres protected from altered hydrology]***

b. Incorporate conservation actions into land planning efforts and public land management plans by local, state, and federal agencies ***[Measure: # of local, state, and federal agency plans incorporating wildlife focused habitat management actions]***

c. Delineate and protect watersheds for seeps, springs and caves with globally rare subterranean aquatic invertebrates ***[Measure: # of watershed areas identified and mapped; # of targeted landowners participating in conservation programs]***

d. Protect groundwater supply feeding springs inhabited by GCN species ***[Measure: average and minimum annual groundwater flow maintained at priority sites; water quality maintained at priority sites]***

e. Work with Bureau of Mines to protect mines supporting GCN species ***[Measure: # of joint cooperative projects implemented; # of mines protected]***

f. Limit access to minimize human disturbance ***[Measure: # of sites with limited access]***

g. Educate spelunkers about the value of these habitats and the impacts of disturbance to caves and mines supporting GCN species ***[Measure: # of educational materials developed and distributed]***

h. Protect known sites from future strip mining or development of surrounding forests *[Measure: # of sites protected]*

i. Install and maintain appropriate gates at entrances to caves and mines that support GCN species *[Measure: # of gates installed and maintained]*

j. Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*

k. Incorporate best management practices into land management plans *[# of development projects and other land management plans implementing BMPs]*

l. Add sites to Maryland Natural Areas Registry (MNAR) *[Measure: MNAR program developed; # of sites with landowners participating in MNAR]*

m. Use registry or acquisition to restore and protect groundwater aquifers *[Measure: # of acres conserved]*

n. Initiate measures to prevent pollution of first and second order streams by surrounding habitat with adequate buffers *[Measure: # of miles of adequate buffer established]*

o. Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*

p. Minimize or eliminate soil disturbance in estimated catchment basin *[Measure: # of catchment basins identified and mapped; # of acres with management plans that incorporate minimal or no soil disturbance]*
q. Avoid any degradation or alteration of spring areas *[Measure: # of springs protected]*
r. Conserve appropriate corridors for movement and dispersal of GCN species *[Measure: # of acres corridors conserved]*
s. Restore forest cover to deforested catchment basins *[Measure: # of acres restored]*
t. Maintain appropriate vegetation around springs *[Measure: # of sites with appropriate surrounding vegetation maintained]*

Inventory, Monitoring and Research Needs:

a. Establish a long-term habitat monitoring program *[Measure: # of monitoring studies established; # of monitoring studies conducted]*
b. Initiate long-term monitoring studies of GCN species, especially bats and invertebrates *[Measure: # of monitoring studies established; # of monitoring studies conducted]*
c. Conduct research on basic ecology, breeding parameters, and life histories of GCN species, especially bats and invertebrates *[Measure: # of research projects conducted; # of research papers published]*
d. Conduct research on habitat use and requirements of GCN species, especially bats and invertebrates *[Measure: # of research projects conducted; # of research papers published]*
e. Conduct species surveys and determine distribution and abundance of GCN species *[Measure: # of surveys completed]*
f. Conduct research to determine movement patterns and dispersal of GCN species, especially bats and woodrats *[Measure: # of research projects conducted; # of research papers published]*
g. Conduct research to determine recharge areas to calculate how large an area is needed to protect GCN species *[Measure: # of research projects conducted; # of research papers published]*
h. Assess and monitor water quality *[Measure: # of monitoring studies conducted; water quality data analyzed and published]*

(22) Coastal Beaches, Dunes, and Mudflats

Description:

In Maryland, coastal beaches, dunes, and mudflats occur along the Atlantic Coast and lower portions of the Chesapeake Bay. These habitats are subject to extreme conditions associated with maritime environments such as salt spray, high winds, flooding, and shifting sands. Beaches are situated in front of primary dunes (foredune) above the mean high tide line and composed of unconsolidated sands and shells, which are constantly being shifted by winds and floods of storm surges and spring high tides. This dynamic disturbance regime severely limits vegetation to salt tolerant, succulent annuals such as American sea rocket and glassworts. In addition, broad overwashed flats may develop behind primary dunes when breaching occurs during storm surges. Extensive construction of high, artificial dunes along the Atlantic coast has reduced the extent of these habitats by increasing oceanside beach erosion and eliminating the disturbance regime that creates and maintains overwashed flats. Most dunes in maritime environments are dominated by grasses and dwarf shrubs well adapted to gradients of soil moisture and salt spray. Sand movement is also an important factor in shaping dune communities. Active dunes, where sand movement is greatest, tend to support grasses such as American beachgrass, beach panic grass, and bitter seabeach grass, whereas stabilized dunes support low growing shrubs such as beach heather. Steep, ocean-fronting dunes are usually colonized by linear, nearly monospecific stands of American beachgrass. The crest and back slopes of primary dunes have a slightly more diverse plant assemblage that may include sea oats, bitter seabeach grass, beach panic grass, seaside goldenrod, seaside spurge, and sanddune sandbur. A series of smaller secondary dunes spreads inward from the primary dune. These dunes are somewhat protected from salt spray and often dominated by beach panic grass.

Small seasonally flooded grasslands in low swales between secondary dunes are commonly referred to as “interdunal swales.” Considered a rare natural community, interdunal swales are characterized by perched water tables and shallow seasonal flooding by rainfall. Although they are predominantely freshwater wetlands, periodic saltwater intrusion may occur in some swales during storm surges. Fluctuations in water levels and salinity vary between swales and greatly influence species composition. As water levels draw down late in the growing season, interdunal swales support a variety of grasses, sedges, rushes, and forbs.

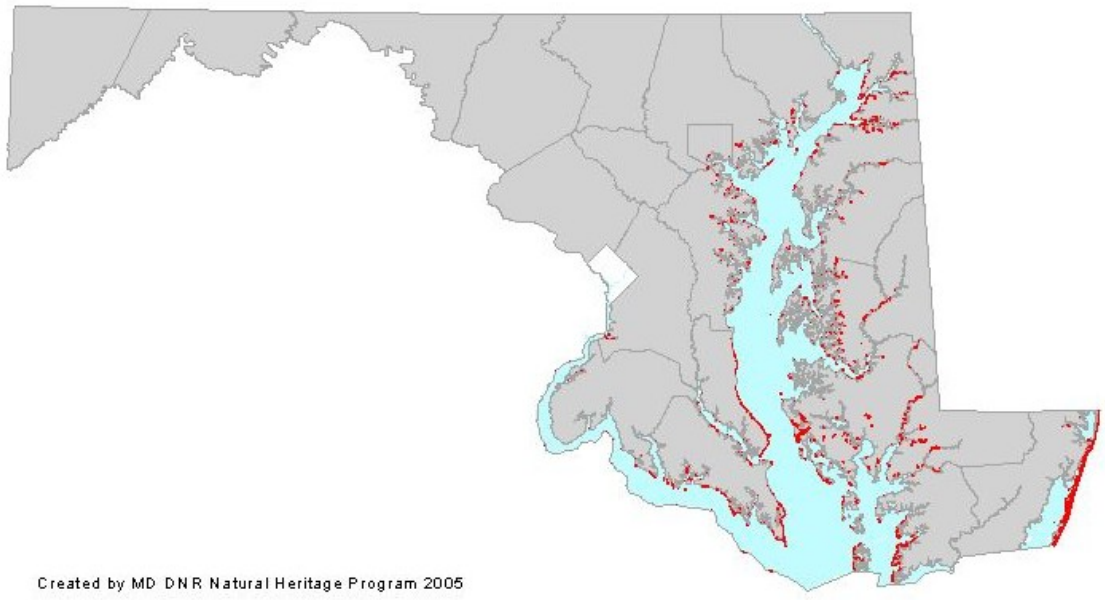
Intertidal mudflats are widely distributed throughout the tidal portions of Maryland, but are most frequent and best developed along large freshwater tidal rivers. These habitats are

subject to regular tidal flooding and exposure cycles twice a day. Substrates are variable depending on region ranging from fine-textured to moderately-coarse alluvium (i.e., unconsolidated sand, silt, clay, or gravel). The vegetation is notably sparse in these habitats, but is typically dominated by herbaceous species adapted to the flooding and exposure cycles. Many of these species seed bank or produce perennial rootstocks enabling them to maintain their viability during long periods of inundation. Intertidal mudflats are typically linear, developing as a narrow band between tidal waters and the edges of marshes, swamps, and even uplands that may abruptly border shorelines. Sparsely vegetated beds of low-growing rosette-leaved aquatics such as Eastern lilaeopsis, American waterwort, kidneyleaf mudplantain, Parker's pipewort, mudwort, and awl-leaf arrowhead are diagnostic of freshwater habitats. Patches of common threesquare, dotted smartweed, and common water willow are also common. In brackish systems, intertidal mudflats are characteristically devoid of vegetation although clumps of saltmarsh cordgrass may occasionally be found. During low tides, beds of seagrass such as Eurasian watermilfoil, eelgrass, and widgeon grass are commonly visible.

Location and Condition:

Coastal beaches and dunes are located in Worcester County on Fenwick and Assateague Islands. Assateague Island is under state and federal ownership (Assateague Island State Park and Assateague Island National Seashore) and remains the best example of these habitats despite frequent human use for recreation. The extensive development of Fenwick Island has destroyed much of the original dune system. In addition, the construction of high, artificial dunes and jetties along Fenwick Island has reduced the extent of these habitats by increasing oceanside beach erosion and eliminating the natural processes that create and maintain them. To offset this, large-scale beach replenishment projects are necessary to supplement the low levels of natural on-shore sand deposition. Intertidal mudflats are common along many of the coastal bays and tributaries of the Chesapeake Bay. The majority of these habitats are in good condition although sedimentation, runoff, boat wakes, and ditching of adjacent marshes remain a constant threat.

Figure 4.22 Location of Coastal Beaches, Dunes, and Mudflats in Maryland (Sources: MD DNR NHP; NPS Assateague Island National Seashore; USFWS NWI)



GCN Species, Rare Natural Communities, and Other Wildlife:

Mammals
Least shrew
Birds
American black duck
American oystercatcher
American peregrine falcon
Bald eagle
Black skimmer
Black tern
Black-bellied plover
Black-crowned night-heron
Boat-tailed grackle
Brant
Brown pelican
Common tern
Dunlin
Eastern meadowlark
Forster's tern
Glossy ibis
Grasshopper sparrow
Great blue heron

Great egret
Greater yellowlegs
Gull-billed tern
Harlequin duck
Laughing gull
Least tern
Little blue heron
Piping plover
Purple sandpiper
Red knot
Roseate tern
Royal tern
Ruddy turnstone
Sanderling
Sandwich tern
Semipalmated sandpiper
Short-billed Dowitcher
Snowy egret
Tricolored heron
Whimbrel
Willet

Wilson's plover
Wilson's snipe
Yellow-crowned night-heron
Reptiles
Loggerhead seaturtle
Northern diamond-backed terrapin
Inverts: Beetles
A lampyrid firefly
Ghost tiger beetle
Northeastern beach tiger beetle
White tiger beetle
Inverts: Marine Arthropods
Horseshoe crab
Rare Natural Communities
Maritime Dune Grasslands
Interdunal Swales
Intertidal Mud/Sand/Gravel Flats
Coastal Beaches and Overwash Flats

In addition to the GCN species listed above, this key wildlife habitat supports a wide diversity of wildlife species. The following game species are found in this habitat type: red fox, common raccoon, eastern cottontail, Canada goose, snow goose, brant, mallard, and American black duck. Management plans and conservation programs for these game species are currently being implemented by MD DNR, USFWS, and many other partners.

Threats:

a. Conversion to other land uses or habitat types that results in loss of habitat
b. Pesticide use and contamination that directly or indirectly affects GCN species
c. Human disturbance and other incompatible practices that result in habitat degradation
d. Invasive species that result in habitat degradation
e. Lack of scientific understanding of appropriate habitat requirements and management for all GCN species
f. Climate change, sea-level rise, and shoreline erosion that result in modification of natural processes
g. Inappropriate shoreline erosion control practices
h. Sedimentation
i. Oil spills
j. Fragmentation
k. Dune crossings, driving, and recreation on beaches that result in habitat degradation

Conservation Actions:

a. Develop and implement shore erosion control practices that are compatible with beach and dune maintenance ***[Measure: guidelines developed; # of sites with compatible management implemented]***

b. Ensure that land-use planning and zoning decisions are done in an appropriate manner to reduce impacts to these habitats ***[Measure: # of local planning and zoning processes incorporating wildlife focused habitat protection]***

c. Manage feral horse population on Assateague Island to reduce adverse impacts ***[Measure: % of population managed; # of acres with reduced adverse impacts]***

d. Restore functional dunes and native vegetation ***[Measure: # of acres restored]***

e. Incorporate conservation actions into land planning efforts and public land management plans by local, state, and federal agencies ***[Measure: # of local, state, and federal agency plans incorporating wildlife focused habitat management actions]***

f. Limit access and educate the public about the value of these habitats to minimize human disturbance ***[Measure: # of sites with limited access; # of educational materials developed and distributed]***

g. Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*

h. Incorporate best management practices into land management plans *[Measure: # of development projects implementing BMPs]*

i. Restore tidal flows to marshes and create tidal open water flats *[Measure: # of acres restored]*

j. Utilize Coastal Bays Program to influence land use decisions and educate the public *[Measure: # of existing programs incorporated into land planning efforts; # of educational materials developed and distributed]*

k. Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*

l. Improve and maintain water quality *[Measure: # of sites with management implemented]*

m. Minimize risk of oil spills and respond immediately to contain spills when they occur *[Measure: # of protocols developed and evaluated for effectiveness; # of immediate responses]*

Inventory, Monitoring and Research Needs:

a. Conduct long-term monitoring studies of certain GCN species, including piping plover, least tern, and shorebirds *[Measure: # of monitoring programs established; # of monitoring programs conducted]*
b. Conduct inventories for certain GCN species, especially invertebrates *[Measure: # of inventories completed]*
c. Conduct research on movement patterns, dispersal and basic biology of certain GCN species *[Measure: # of research projects conducted; # research papers published]*
d. Conduct research on habitat requirements to gain a better understanding of threats in general and area sensitivity needs of certain GCN species *[Measure: # of research projects conducted; # research papers published; # of threats and conservation actions modified and re-prioritized based on models]*
e. Conduct monitoring of invasive species that affect GCN species and their habitat *[Measure: # of monitoring programs established; # of monitoring programs conducted]*